Revolutionizing Water Quality Monitoring with IoT-Enabled Devices

Yuvanth Yerra, Tarun Sarjana, Shiva Teja Pulabala and V R Seshagiri Rao

May 17, 2023

REVOLUTIONIZING WATER QUALITY MONITORING WITH IOT-ENABLED DEVICES

[1] Yuvanth Yerra
Department of Electronics and Communication Engineering
Institute of Aeronautical Engineering
Hyderabad, Telangana
yuvanthyerra@gmail.com

[2] Tarun Sarjana
Department of Electronics and Communication Engineering
Institute of Aeronautical Engineering
Hyderabad, Telangana
tarunofficial.1309@gmail.com

[3] Shiva Teja Pulabala
Department of Electronics and Communication Engineering
Institute of Aeronautical Engineering
Hyderabad, Telangana
shivatejapulabala777@gmail.com

[4] Mr V R Seshagiri Rao
Department of Electronics and Communication Engineering
Institute of Aeronautical Engineering
Hyderabad, Telangana
vrsrao@iare.ac.in.

***Abstract*— Water utilities face significant challenges in ensuring the safety and purity of drinking water, especially given the growing population and finite water supplies. To solve this problem, a novel approach has been put up that employs the Internet of Things (IoT) to continuously monitor the level or degree of purity, cleanliness, and safety of water for various purposes, such as drinking, swimming, and irrigation. This system is made up of numerous device nodes that gather information on different parameters like temperature, pH, turbidity, and water level. The information is then uploaded to the Thingspeak cloud using a wireless Arduino microcontroller transmission. The system also features a Blynk app for sending notifications in case of abnormal water conditions, as well as an LCD screen for displaying water quality parameters.**

The implementation of an IOT-enabled advanced water quality surveillance system has enabled real-time & cost-effective observation of water quality parameters. This allows water utilities to respond quickly to any changes in water conditions and ensure that safe water is distributed to the public. The system is accessible from anywhere in the world as the data is regularly updated on the server. Implementing IoT in water quality observation is a significant step towards ensuring that everyone has access to safe drinking water. Overall, the system offers an effective and economical approach to overcome the challenges faced by water utilities in maintaining the quality of drinking water.

Keywords*— *WSN (Wireless Sensor Networks), Water Parameters, IOT (Internet of Things), WI-FI (Wireless Fidelity).

I. INTRODUCTION

The acceptability of water for different applications or processes is referred to as **"Water Quality"** and can be characterized by a variety of factors. Specific limitations may apply depending on the intended usage, such as pH and temperature restrictions for water supporting aquatic life or limits on the amounts of harmful substances in drinking water. Managing water adequacy often involves balancing the demands of different users. Natural habitats are essential to this process because they act as sensitive sensors of changes in the general quality of the water.

Wireless Fidelity (Wi-Fi) is a communication technology that operates on radio frequency to facilitate the transmission of data over the airwaves. It uses frequency division multiplexing technology and runs in the 2.4 GHz band at an initial speed of 1-2 Mbps. The normal range is 40 to 300 ft.

Key indicators of water quality are measured by this research using a variety of sensors, including the LM35 sensor for temperature check, pH sensor, turbidity sensor, and water level sensor. These parameter values are continuously updated by the Arduino UNO microcontroller and sent to the Thingspeak cloud over the esp8266 Wi-Fi module. Additionally, output is shown on an LCD module. The Arduino uses the Blynk software to send notifications to the user's mobile device whenever any anomalous sensor data is found.

II. LITERATURE REVIEW

The research article examines several approaches and sensors used for water quality monitoring. The idea of a sensor cloud is also explored by the author. The utilization of technical expertise and cost-effective practises aids in enhancing water quality and raise public awareness, even though it may not be possible to totally improve water quality automatically.[1]

The authors stress the value of ongoing monitoring to guarantee a safe water supply. Sensors are used in the proposed system to measure variables like pH, turbidity, and temperature. The measured values are processed by a microcontroller and sent over the Zigbee protocol to a core controller, the Raspberry Pi. Cloud computing enables the viewing of sensor data on an internet browser application.[2]

After the financial crisis of 2008, the Smart City Initiative was developed in response to the need to build sustainable city models and enhance citizen quality of life. IoT-based water quality monitoring system development for smart cities encompasses not only technical but also financial, social, and ethical considerations. IoT is employed in the Industry 4.0 concept to create intelligent products with their own intelligence that are used during production and subsequent handling, including ongoing product lifetime monitoring. IoS and IoE, which deal with intelligent logistics and transportation as well as the efficient use of resources like power, water, and oil, are also essential components of Industry 4.0.[3]

This framework maintains energy efficiency over time without lowering levels of QOI, is transparent and compatible with simpler protocols. The idea of "sensor-to-task relevancy" that takes into account both a task's QOI needs and a sensor's sensing capabilities is introduced by the authors. They suggest a novel method for choosing sensors to carry out a task over time dubbed the "critical covering set". Under service delay constraints, the energy management choice is chosen dynamically during runtime to optimize long-term traffic statistics. Through a case study on employing sensor networks to monitor water levels, the authors present their concepts and proposed algorithms. They also simulate how well the algorithms operate.[4]

The system uses sensors to detect pH, turbidity, conductivity, and temperature. An Arduino controller accesses the sensors and uses them to retrieve the data to analyse it. The amount of water pollution can be rigorously studied with the use of IoT. The technology may also notify people about the water quality as well as concerned authorities. The system is simple to install close to the water supply that has to be monitored, and the monitoring work can be completed with little training. The suggested model delivers real-time water quality information for prompt action, is accurate, economical, and requires little in the way of human resources.[5]

The suggested system makes use of sensors to monitor variables including conductivity, pH, and turbidity, and the data is uploaded online for analysis. The core controller has a Wi-Fi module incorporated in that enables remote water quality monitoring. The system also includes an alerting mechanism to inform users of any deviations from the target water quality criteria. The technology is made to deploy quickly and interface with current water pipelines. The researchers propose that the system might be further enhanced by including algorithms for water quality anomaly identification.[6]

In order to evaluate the performance of the system and provide a comprehensive assessment of the current status of IoT-based smart water quality monitoring systems, the researchers conducted simulations and experiments. The findings of their study showcase the efficacy of these systems in measuring water quality parameters and present valuable insights into their performance based on rigorous simulations and empirical data.[7]

In this research, a wireless sensor network (WSN) and IoT-based water quality monitoring system is presented. It is intended to offer clean drinking water in rural locations where access to safe drinking water is limited. The system has a variety of sensors to detect different aspects of water quality, and the authors test and simulate how well it performs.[8]

The system uses sensors to assess many aspects of water quality, including temperature, turbidity, and pH. Results from simulations and experiments help the authors verify the system's effectiveness.[9]

A Raspberry Pi is connected to the proposed system's different sensors, including pH, turbidity, and temperature sensors, using an analog-to-digital converter (ADC). Without any human involvement, the entire process is completed quickly and with minimal effort. The system then verifies that the parameters measuring the water quality are within the specified range. The system's components are inexpensive, adaptable, and extremely effective.[10]

III. EXISTING FRAMEWORK

The existing framework for the project “Internet of Things Enabled Advanced Water Quality Surveillance System” include traditional methods like:

1) *CHEMICAL TESTING*

One of the oldest methods for water quality monitoring involves chemical testing. This method involves adding chemical reagents to water samples to detect and measure various water quality parameters. For example, pH can be measured using indicator dyes, while chlorine levels can be detected using colorimetric tests. While chemical testing can be accurate, it can also be time-consuming and require specialized equipment and training.

2) *BIOASSAYS*

Bioassays involve using living organisms to detect water quality parameters. For example, the presence of certain pollutants or toxins can be detected using algae or other microorganisms. Bioassays can be more cost-effective than chemical testing, and can provide real-time monitoring of water quality. However, they can also be less precise and may require specialized expertise to interpret the results.

3) *VISUAL INSPECTION*

Visual inspection involves physically examining water samples for signs of contamination or other water quality issues. For example, water samples can be examined for visible particles or discoloration, which may indicate the presence of pollutants or other contaminants. While visual inspection is a simple and inexpensive method, it can also be less accurate than other methods and may not detect all water quality issues.

4) *TASTE AND ODOUR TESTING*

Taste and odour testing involves tasting and smelling water samples to detect changes in water quality. For example, a change in the taste or odour of water may indicate the presence of pollutants or other contaminants. While taste and odour testing can be a simple and effective method, it can also be subjective and may not detect all water quality issues.

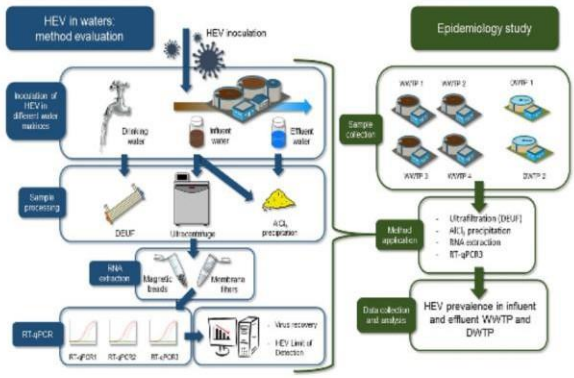

Fig 3.1: Existing Method For Revolutionary Water Quality Monitoring for IOT-Enabled Devices.

In conclusion, while digital circuits and IoT-based monitoring systems are becoming increasingly common for water quality monitoring, there are also existing methods that do not involve digital circuits. These methods can be useful in situations where digital monitoring is not possible or practical, or where a simpler and more cost-effective approach is needed. However, these methods may also have limitations in terms of accuracy, precision, and sensitivity, and may not be suitable for all water quality monitoring applications. Some of the digital circuits like machine- learning, ultra sensor applications and high circuit fabrications can be very complex for human understanding and it is very costly to maintain the project.

IV. PROPOSED FRAMEWORK

The Arduino Uno microcontroller board uses the ATmega328 processor. It is a member of the AVR family and has a 16MHz ceramic resonator, 6 analogue pins, and 14 digital input/output pins. The board makes use of a USB connection, a power jack, and a reset button.

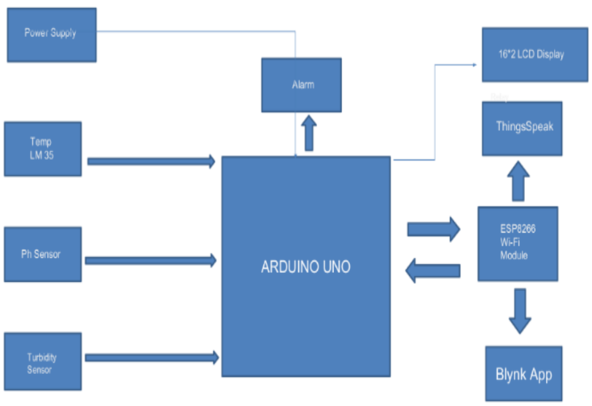

Fig 4.1 Block diagram

A. HARDWARE COMPONENTS

1) REGULATED POWER SUPPLY

The Power supply is a fundamental and indispensable component within an electrical system, fulfilling the critical role of providing a reliable source of electrical energy to power an output load. Its primary function is to transform and regulate incoming electrical energy from the input source, ensuring that the supplied voltage and current meet the precise requirements of the intended load or loads. This pivotal function underscores the power supply's significance in enabling the smooth operation and optimal performance of electronic devices and systems, rendering it a paramount consideration in research and development pursuits. The term "power supply unit" (PSU) refers to a device or system that converts electrical energy from an input source into a usable form of energy for the connected loads. While the term "power supply" can also refer to mechanical or other types of energy sources, it is primarily used to describe electrical energy sources in various applications.

2) LM 35 TEMPERATURE SENSOR

The LM35 sensor series comprises of precision IC temperature sensors that exhibit a linearly proportional output voltage with respect to the temperature measured in Celsius (Centigrade), making it an ideal choice for applications requiring high accuracy temperature measurements. The present study provides a comprehensive review of the functional properties and technical specifications of the LM35 series temperature sensors, highlighting their suitability for various temperature sensing applications in diverse domains.

Temperature sensors are utilized to measure the thermal energy generated during a fire, making them an essential tool in fire detection and safety systems. The present study provides a detailed overview of the role of temperature sensors in fire detection and safety, highlighting their importance in preventing and mitigating the damage caused by fire incidents.

3) PH SENSOR

The potentiometric pH meter serves as a vital scientific apparatus utilized for the precise determination of acidity or alkalinity in aqueous solutions, accomplished through the measurement of hydrogen-ion activity. This instrumental device effectively detects variations in electrical potential between a dedicated pH electrode and a reference electrode, thereby establishing a direct and proportional relationship with the pH or acidity level of the analyzed solution. Due to its accuracy and reliability, the pH meter has gained significant prominence in quality control processes and laboratory experiments, rendering it an indispensable tool in scientific research.

4) TURBIDITY SENSOR

The Arduino Turbidity Sensor is an effective tool for measuring water turbidity and assessing its quality, as it utilizes an infrared light emitted from its end to detect suspended particles in water. The sensor's ability to measure light transmittance and particle dispersion, which varies based on the level of Total Suspended Solids (TSS), allows for the determination of turbidity levels in liquids. This sensor is commonly employed in projects that monitor water turbidity in various settings, including rivers, streams, lakes, catchment areas, research locations, laboratories, and liquid tanks. Additionally, the sensor features an end that can be directly immersed in the liquid and an electronic module that amplifies and transmits data to the project's microcontroller, making it a versatile and reliable tool for assessing water quality.

5) WATER LEVEL SENSOR

The sensor comprises a total of ten exposed copper traces, consisting of five power traces and five sense traces, with each sense trace placed between every two power traces in an interlaced pattern. Typically unconnected, these traces form a bridge when the sensor is submerged in water. Additionally, a Power LED is present on the board, which illuminates when the board is powered. The water level sensor operates by utilizing a variable resistor composed of a series of exposed parallel conductors that change in resistance based on the level of water. The resistance is inversely correlated to the depth of the water: The more water the sensor is submerged in, the better its conductivity and the lower its resistance will be. The sensor's conductivity will be low and its resistance will increase the less water it is submerged in. To determine the water level, the sensor's corresponding output voltage can be measured in accordance with the changing resistance of the exposed parallel conductors.

6) ESP 8266 WIFI-MODULE

The ESP8266 Wi-Fi Module is a comprehensive System on Chip (SoC) that boasts an autonomous and self-contained architecture. It features a built-in TCP/IP protocol stack, enabling seamless connectivity to Wi-Fi networks for any microcontroller. Notably, it excels in efficiently shouldering the entire gamut of Wi-Fi networking tasks, effectively relieving the burden from an auxiliary application processor.

Additionally, the module can independently serve as a host for applications, further showcasing its versatility and functionality. This characteristic renders the ESP8266 Wi-Fi Module a valuable asset in research and development endeavors. With pre-programmed AT command set firmware, the ESP8266 module offers extensive Wi-Fi functionality without the need for an additional Wi-Fi Shield. Its highly integrated design requires minimal external circuitry, and its front-end module is designed to take up minimal space on a printed circuit board (PCB).

7) LCD DISPLAY

When utilizing a battery as the power source, it is important to take into account that piezo sounders consume lower current compared to buzzers. Moreover, buzzers are limited to producing a single tone, whereas piezo sounders offer the capability to generate sounds with various tones. To activate a buzzer, the signal should be set to a high state (1), and to deactivate it, the signal should be set to a low state (0).

B. SOFTWARE REQUIREMENTS

1) EXPRESS PCB

When designing a project, the final product should ideally have a well-organized PCB, minimal cables, and be able to pass a shake test. While breadboards offer significant flexibility for prototyping, proper PCBs are stronger and more reliable due to the absence of cables that may come loose. For PCB design intended for fabrication by Express PCB only (as other PCB manufacturers do not accept Express PCB files), a software program called Express PCB is commonly used, although it has a few limitations despite its ease of use.

2) INTERFACE

When launching a project in PCB design software, a yellow outline appears to indicate the dimensions of the PCB. While this outline is typically cropped to the correct size after placing and moving components and traces, it is important to crop the PCB to the correct size before beginning when designing a board with specific size restrictions.

3) ARDUINO IDE COMPILER

This tutorial serves as a complementary guide to any Arduino on a Breadboard tutorial and assumes that a microcontroller with an already installed bootloader is available, or one must be loaded onto the chip. It is important to note that not all ATmega328 microcontrollers are created equal, and the presence of a bootloader is essential as it is responsible for executing the code that governs the uploading of prints onto the IC(Integrated Circuit).

V. RESULTS AND DISCUSSIONS

The " Revolutionizing Water Quality Monitoring With IOT-Enabled Devices" is a sophisticated system for monitoring water quality that makes use of both hardware and software elements to gather and process data in real-time. Sensors for measuring various aspects of water quality are included in the hardware, together with an Arduino Uno microcontroller for data processing and communication. For data visualization and remote access, the software components also include the Blynk app and Thingspeak cloud.

The system's ability to collect and analyze data provides valuable insights into water quality trends and patterns that may indicate potential issues. By analyzing the data, the system can detect trends and patterns that may indicate potential water quality issues, which can help in decision-making about water management practices. The system's real-time monitoring capability improves response times to potential water quality issues, while also reducing the risk of human error in manual monitoring methods.

The smart water quality monitoring system also offers numerous benefits for water management practices, including improving the efficiency and cost-effectiveness of water management practices. By automating the water quality monitoring process, the system reduces the need for manual labor and minimizes the potential impact of water quality issues.

Moreover, the system's ability to easily access and analyze water quality data can help to inform the public about water quality and provide valuable insights into water management practices. This can increase public awareness and support for water management initiatives, improving the overall sustainability of water resources.

In summary, the smart water quality monitoring system offers numerous benefits for water management practices by providing real-time monitoring, improving data accuracy, and enabling data analysis. It has the potential to enhance water quality management and promote sustainable water resource management practices.

Fig 5.1: LCD Display

Fig 5.2:Thingsepak **Fig 5.3: Blynk App**

VI. CONCLUSION AND FUTURE SCOPE

In conclusion, The project's hardware components were precisely integrated, and each module was positioned for maximum efficiency. Advanced ICs and technology advancements were utilized, resulting in a successful implementation of the project. Thorough testing has confirmed that the final design is reliable and efficient. This meticulous approach to hardware integration and technology utilization has ensured the overall success and functionality of the unit.

The system could be further improved by incorporating additional data analysis tools to better interpret the collected information. Integrating wireless communication methods, such as Wi-Fi or Bluetooth, could also enhance the functionality and accessibility of the system. The addition of a user-friendly interface, such as a mobile application, could allow for easier monitoring and control. Incorporating real-time monitoring capabilities, such as remotely accessible live data streams, could provide more immediate and accurate information. Integrating the system with other existing water management systems, such as a smart irrigation system, could further improve overall water management practices.

REFERENCES

[1] Nikhil Kedia, Water Quality Monitoring for Rural Areas- A Sensor Cloud Based Economical Project, in 1st International Conference on Next Generation Computing Technologies (NGCT-2015) Dehradun, India, 4-5 September 2015. 978-1-4673-6809-4/15/$31.00 ©2015 IEEE.

[2] Jayti Bhatt, Jignesh Patoliya, Iot Based Water Quality Monitoring System, IRFIC, 21feb,2016.

[3] Michal lom, ondrej priby & miroslav svitek, Internet 4.0 as a part of smart cities, 978-1-5090-1116-2/16/$31.00 ©2016 IEEE.

[4] Zhanwei Sun, Chi Harold Liu, Chatschik Bisdikia_, Joel W. Branch and Bo Yang, 2012 9th Annual IEEE Communications Society Conference on Sensor, Mesh and Ad Hoc Communications and Networks.

[5] Tha. Sugapriyaa, S. Rakshaya, K. Ramyadevi, M. Ramya, P.G. Rashmi (2018), Smart Water Quality Monitoring System for Real Time Applications, International Journal of Pure and Applied Mathematics, Volume 118, No. pp 1363-1369.

[6] Geetha, S., Gouthami, S.(2016) Internet of things enabled real time water quality monitoring system. Smart Water 2, 1. https://doi.org/10.1186/s40713-017-0005-y

[7] Real-Time Water Quality Monitoring System Based on IoT Technology by S. K. Saini, S. K. Arya, and M. K. Sharma. Procedia Computer Science, 2018

[8] A Wireless Sensor Network-Based Water Quality Monitoring System for Drinking Water Safety in Rural Regions by Z. Gao, J. Wang, and Q. Guo. Sensors, 2016

[9] IoT Based Smart Water Quality Monitoring System using Wireless Sensor Networks by K. Sriharsha, M. Venkatesh, and B. Siva Sai Sreenivas

[10] B. Sengupta, S. Sawant, M. Dhanawade, S. Bhosale Water quality monitoring using IoT Int. Res. J. Eng. Technol., 6 (2019), pp. 695-701